TITLE OF THE INVENTION

COMMUNICATION SYSTEM TO WHICH MULTIPLE ACCESS CONTROL METHOD IS APPLIED

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to communication systems, and more particularly to a communication system in which a transmitting station and a receiving station are communicably connected through a transmission path, and the receiving station reserves a bandwidth, which is used in data communication, for the transmitting station in advance.

Description of the Background Art

Conventionally, a multiple access method has been applied to some communication systems. As an example thereof, "Splid-channel Reservation Multiple Access" (IEEE Trans. Commun., vol. COM-24, pp. 832 to 845, Aug. 1976) is described next below by referring to FIG. 16. The communication system shown in FIG. 16 includes a central station 121, which controls bandwidths for communication, and secondary stations 122 and 123. Hereinafter, a description is made for a case where the secondary stations 122 and 123 transmit data to the central station 121.

INS A1 A1 For data transmission, the secondary stations 122 and 123 first transmit request packets 124 and 125 to the central station

121 using a channel for reservation. After receiving the request packets 124 and 125, the central station 121 schedules timing for data packet transmission so as to reserve bandwidths for the secondary stations 122 and 123. And then, the central station 121 creates a response packet 126 for transmission to a channel for response.

The secondary stations 122 and 123 respectively receive and analyze the response packet 126 to find which bandwidths are each assigned thereto. Through the assigned bandwidths, the secondary stations 122 and 123 respectively transmit data packets 127 and 128 created in accordance with data.

In such SRMA (Splid-channel Reservation Multiple Access), it is necessary to reserve the bandwidth for every data packet in advance to transfer the same. In other words, data packet transmission always follows bandwidth reservation.

For bandwidth reservation, the request packets 124 and 125 and the response packet 126 are transmitted and received. The time requisite for transmission and reception thereof results in heavy overhead and bandwidth usage to a considerable degree.

Further, the stations 122 and 123 are allowed to freely send out the request packets 124 and 125 to any channel for reservation. Accordingly, the request packets 124 and 125 may come into communication collision with each other if being transmitted with the same timing.

If this is the case, the central station 121 cannot

correctly receive the collided request packets 124 and 125, and thus cannot create the response packet 126 for transmission. Therefor, the stations 122 and 123 are required to transmit the once-transmitted request packets again, thereby rendering the data communication delayed.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to implement a communication system in which bandwidths are effectively utilized by reducing time for bandwidth reservation.

Another object of the present invention is to implement a communication system in which time between generating and transmitting data is shortened.

A first aspect of the present invention is directed to a communication system in which a transmitting station and a receiving station are communicably connected through a transmission path, and the receiving station reserves a bandwidth used in data communication for the transmitting station in advance, wherein the transmitting station transmits a reservation request packet for bandwidth reservation to the receiving station when data to be transmitted is generated, the receiving station reserves the bandwidth in response to the reservation request packet from the transmitting station, and transmits a communication reservation packet for informing the transmitting station of the reserved bandwidth, the transmitting station

creates a data packet according to the generated data, and transmits the created data packet through the bandwidth informed by the communication reservation packet from the receiving station, and the receiving station stores a valid period of the bandwidth reserved for the transmitting station, and voluntarily and repeatedly transmits the communication reservation packet to the transmitting station during the stored valid period.

In the conventional SRMA, a request packet corresponding to the reservation request packet and a response packet corresponding to the communication reservation packet are always exchanged immediately before data communication.

INS A2

A2 ~~However, in the first aspect, after received one reservation request packet, a receiving station voluntarily and repeatedly transmits the communication reservation packet as long as the valid period is valid. In other words, a transmitting station only needs to transmit the reservation request packet once so that the once-reserved bandwidth assigned therefor is available for the duration of the valid period. In this manner, in the first aspect, the number of transmitting the reservation request packet is decreased, and accordingly the overhead can be reduced. Accordingly, it becomes possible to implement the communication system in which the bandwidths are effectively utilized.~~

According to a second aspect, in the first aspect, an initial value of the valid period stored for the transmitting

station is predetermined, and the receiving station further shortens the stored valid period with given timing, lengthens the stored valid period on reception of the data packet from the transmitting station, deletes the valid period when the valid period is equal to a predetermined reference value, and voluntarily and repeatedly transmits the communication reservation packet to the transmitting station as long as the valid period is stored.

In the second aspect, the receiving station shortens the valid period with a predetermined timing, and lengthens it after receiving the data packet. Accordingly, the more data is transmitted from the transmitting station, the longer the valid period becomes, and vice versa. In this manner, since the bandwidth to be assigned can be changed in volume according to the volume of data transmitted in the transmitting station, and therefore the bandwidths can be effectively utilized in this communication system.

According to a third aspect, in the second aspect, the transmitting station further sets an identifier assigned thereto to the reservation request packet, and the receiving station further stores the identifier set to the reservation request packet transmitted from the transmitting station together with the initial value of the valid period, and when deletes the valid period, deletes the stored identifier together therewith.

In the third aspect, the receiving station registers the

identifier and the valid period of the transmitting station as a set. In this manner, even if the communication system includes a plurality of transmitting stations, the transmitting stations can be uniquely identified. Accordingly, the communication system can employ a number of stations.

According to a fourth aspect, in the first aspect, the receiving station further transmits, with given timing, a request inquiry packet for allowing the transmitting station to transmit the reservation request packet, and the transmitting station further transmits the reservation request packet in response to the request inquiry packet transmitted from the receiving station.

In the fourth aspect, the receiving station transmits the request inquiry packet with a given timing. Therefore, the transmitting station can find, with reliability, the right time to transmit the reservation request packet.

According to a fifth aspect, in the fourth aspect, the receiving station further sets, to the request inquiry packet, a probability that the transmitting station can transmit the reservation request packet, and the transmitting station further transmits the reservation request packet according to the probability value included in the request inquiry packet transmitted from the receiving station.

In the fifth aspect, the transmitting station transmits the reservation request packet according to the probability value.

To be specific, the lower the probability value becomes, it gets more difficult for the transmitting station to transmit the reservation request packet. Accordingly the reservation request packet hardly collides with others on the transmission path. In this manner, time taken before data packet transmission can be shorter than the conventional SRMA.

According to a sixth aspect, in the fifth aspect, when the receiving station detected a communication collision on the transmission path, the probability value set to the request inquiry packet is relatively low.

In the sixth aspect, the probability gets relatively low when any communication collision is detected on the transmission path. Accordingly, it gets more difficult for the transmitting station to transmit the reservation request packet. In this manner, at least after some communication collision is detected, the reservation request packet hardly collides with others on the transmission path.

INS A3

A3 ~~According to a seventh aspect, in the fifth aspect, when the receiving station correctly received the reservation request packet from the transmission path, the probability value set to the request inquiry packet is relatively high.~~

According to an eighth aspect, in the fifth aspect, when no signal arrives the receiving station from the transmission path for a given time period, the probability value set to the request inquiry packet is relatively high.

In a case where the receiving station correctly receives the reservation request packet, or where the receiving station has no incoming signal for a predetermined time, the transmission path is not congested. In such cases, in the seventh and eighth aspects, the probability to be set is relatively high, and it accordingly gets easier for the transmitting station to transmit the reservation request packet.

According to a ninth aspect, in the second aspect, the receiving station further changes a time interval between two communication reservation packets according to the valid period.

According to a tenth aspect, in the first aspect, the receiving station further changes a time interval between two communication reservation packets according to a transfer rate required by the transmitting station.

In the ninth and tenth aspects, a time interval between two communication reservation packets is changed according to the valid period or requiring transfer rate on the transmitting station side. In this manner, transfer rate from the transmitting station to the receiving station is varied, and thus the communication system can be provided with more flexibility.

According to an eleventh aspect, in the first aspect, when no signal arrives the receiving station from the transmission path for a given time period, the receiving station further judges that the communication reservation packet can be transmitted.

According to a twelfth aspect, in the first aspect, the

receiving station further judges that the communication reservation packet can be transmitted on reception of the data packet from the transmission path.

According to a thirteenth aspect, in the first aspect, the transmitting station further judges that the reservation request packet can be transmitted on reception of the data packet or the communication reservation packet from the transmission path.

With each timing described in the eleventh to thirteenth aspects, the possibility for the transmission path being congested is low. Accordingly, the data packet or the reservation request packet transmitted from the transmitting station or the receiving station hardly collides with others on the transmission path.

According to a fourteenth aspect, in the first aspect, when no signal arrives the receiving station from the transmission path for a given time period, the transmitting station further judges that the reservation request packet can be transmitted.

According to a fifteenth aspect, in the first aspect, the transmitting station further judges that the data packet can be transmitted on reception of another data packet from the transmission path.

According to a sixteenth aspect, in the first aspect, the transmitting station further measures a lapse of time after transmitted the data packet, and when the lapse of time becomes equal to a reference value relevant to the valid period, judges

that the reservation request packet can be transmitted.

In the conventional SRMA, the request packet corresponding to the reservation request packet is transmitted via a channel for reservation.

However, in the fourteenth to sixteenth aspects, the transmitting station has data for transmission and determines that the reservation request packet can be transmitted with any timing described in these aspects. To be specific, in this communication system, the transmitting station has no more need to wait for a time frame to which the channel for reservation is set. Accordingly, in the transmitting station, time between generating the data for transmission and transmitting the reservation request packet (i.e., time before data communication) can be shortened.

Further, with each timing described in the fifteenth to seventeenth aspects, the transmission path is not so congested, because packet exchange is over. The reservation request packet being sent out from the transmitting station with such timings, it becomes possible to provide the communication system in which the bandwidths are more effectively utilized, and the transmitted reservation request packet hardly collides with others on the transmission path.

These and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when

taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing the entire structure of a communication system CS according to an embodiment of the present invention;

FIG. 2 is a sequence chart roughly illustrating the first half of a communication procedure carried out in the communication system CS in FIG. 1;

FIG. 3 is a sequence chart roughly illustrating the second half of the communication procedure carried out in the communication system CS in FIG. 1;

FIGS. 4a to 4d are diagrams each showing a frame format of each packet exchanged in the communication system CS in FIG. 1;

FIG. 5 is a main flowchart illustrating the procedure carried out by a receiving station 1_R;

FIG. 6 is a detailed flowchart illustrating the procedure for a reservation phase on the receiving station 1_R side;

FIG. 7 is a detailed flowchart illustrating a data communication phase on the receiving station 1_R side;

FIG. 8 is a main flowchart illustrating the procedure carried out by a transmitting station 1_T;

FIG. 9 is a detailed flowchart illustrating the procedure for a reservation phase on the transmitting station 1_T side;

FIG. 10 is a detailed flowchart illustrating a data

communication phase on the transmitting station 1_T side;

FIGS. 11a to 11c are diagrams each showing information to be registered in a storage device 13_R of the receiving station 1_R;

FIGS. 12a and 12b are diagrams for each illustrating how to disassemble a communication reservation packet 103 and a data packet 104;

FIG. 13 is the first half of a sequence chart exemplarily illustrating how data is transmitted from the transmitting station 1_T to the receiving station 1_R;

FIG. 14 is the second half of a sequence chart exemplarily illustrating how data is transmitted from the transmitting station 1_T to the receiving station 1_R;

FIG. 15 is a sequence chart illustrating how data is exchanged between the transmitting station 1_T and the receiving station 1_R; and

FIG. 16 is a diagram for illustrating a communication system to which SRMA is applied.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a block diagram showing the entire structure of a communication system CS according to an embodiment of the present invention. In the communication system CS, a plurality of communication stations 1 (in the drawing, communication stations 1_a, 1_b, and 1_c are shown) are communicably connected

through a wireless transmission path 2.

The communication stations 1 are provided, in advance, with each different identifier ID, thereby being uniquely identified in the communication system CS. In this embodiment, the communication stations 1_a to 1_c are each provided with the identifiers ID"a" to ID"c".

Once such communication system CS is started, data is transmitted between the communication stations 1. Hereinafter, any communication station 1 which transmits the data is referred to as a transmitting station 1_T, and any other communication station 1 which receives the data is as a receiving station 1_R. In the communication system CS, the receiving stations 1_R reserves bandwidths used in data communication for the transmitting stations 1_T in advance. Hereinafter, a communication procedure for bandwidth reservation is referred to as a reservation phase, and a procedure for data communication a data communication phase.

A typical example for the communication procedure between the receiving stations 1_R and the transmitting stations 1_T is described by referring to sequence charts in FIGS. 2 and 3. Herein, it is described a case where the communication station 1_a operates as the receiving station 1_R, and the communication stations 1_b and 1_c each operate as the transmitting station 1_T.

In the reservation phase, the receiving station 1_R assembles a request inquiry packet 101 so as to make an inquiry about whether any communication station 1 in the communication system CS (except

the receiving station 1_R) is requesting for data communication. More specifically, the receiving station 1_R assembles, as shown in FIG. 4a, the request inquiry packet 101 from a source identifier SID which is the identifier ID assigned thereto, a packet type T, a unique word UW, and a frame check sequence FCS in addition to a transmission probability value P.

The unique word UW is typically the information necessary for the communication stations 1 receiving the request inquiry packet 101 to establish frame synchronization or to identify the bit position of other information subsequent thereto (e.g., packet type T).

The packet type T is the information necessary for the communication stations 1 to identify the received packet as the request inquiry packet 101.

To the source identifier SID, the identifier ID assigned to the receiving station 1_R which assembles the request inquiry packet 101 is set.

The transmission probability value P is later described, and is not now described.

INS A4

A4 The frame check sequence FCS is the code for the communication stations 1 receiving the request inquiry packet 101 to judge whether or not any error is occurred in the request inquiry packet 101, or to correct any error occurred therein.

INS A5

A5 The receiving station 1_R sends out such request inquiry packet 101 to the wireless transmission path 2 so as to make an

inquiry about whether or not any other communication station 1 is requesting for data communication (sequence $Seq1_1$).

Among the communication stations 1, any station having data to be transmitted to the receiving station 1_R (the transmitting station 1_T) receives the request inquiry packet 101 through the transmission path 2 for disassembly. The transmitting station 1_T then assembles a reservation request packet 102 for requesting data communication with the receiving station 1_R, and bandwidth reservation necessary for the data communication. In more detail, the transmitting station 1_T assembles, as shown in FIG. 4b, the reservation request packet 102 from a destination identifier DID, the source identifier SID, the packet type T, the unique word UW, and the frame check sequence FCS in addition to a transfer rate R, which is required for the data communication.

The unique word UW is typically the information necessary for the communication stations 1 receiving the reservation request packet 102 (the receiving station 1_R) to establish frame synchronization or to identify the location of other information subsequent thereto (e.g., packet type T).

The packet type T is the information for identifying the reservation request packet 102. The packet type T accordingly enables the receiving station 1_R to identify the received packet as the reservation request packet 102.

To the source identifier SID, the identifier ID of the transmitting station 1_T which assembles the reservation request

packet 102 is set.

To the destination identifier DID, the identifier ID of the receiving station 1_R which receives the reservation request packet 102 is set.

The transfer rate R is the information indicating the transfer rate necessary for data communication (i.e., bandwidth).

INS A6

The frame check sequence FCS is the code for the communication stations 1 receiving the reservation request packet 102 to judge whether or not any error is occurred in the reservation request packet 102, or to correct any error occurred therein.

The communication station 1_b, which is one of the transmitting stations 1_T, transmits such reservation request packet 102 to the receiving station 1_R through the wireless transmission path 2 for requesting data communication and bandwidth reservation therefor (sequence $Seq2_1$).

The receiving station 1_R repeats the assembly and transmission of the request inquiry packet 101 for M times (where M is a variable, and is an integer equal to or more than 0) (sequence $Seq1_1$ to 1_M) so as to collect requests for data communication from some more transmitting stations 1_T. In this example, the receiving station 1_R presumably assembles and transmits M pieces of request inquiry packets 101 and receives requests for data communication from the communication stations 1_b and 1_c.

After such collection, the receiving station 1_R reserves, for each of the requesting transmitting stations 1_T, a bandwidth

necessary for data communication so as to determine how many communication reservation packets 103 are to be transmitted in total N (where N is a variable, and is an integer equal to or more than 0). Herein, the number N is determined in relation to the bandwidths necessitated by the transmitting stations 1_T for data communication. Immediately after the startup of the communication system CS, the number N is preferably a value which ensures the transfer rate R required by each transmitting station 1_T which transmitted the reservation request packet 102. Note that, since each transmitting station 1_T can freely request the requiring transfer rate R to the receiving station 1_R, the determined number N may be not always ensure the transfer rate R desired by every transmitting station 1_T.

One of the features of the present invention is to generate information referred to as valid period VP for every transmitting station 1_T after the receiving station 1_R reserved a bandwidth therefor. The valid period VP is the value denoting how long each bandwidth reserved for the transmitting stations 1_T is valid, and an initial value thereof is VP_0. In this example, valid periods VP_b and VP_c whose initial values are each VP_{0b} and VP_{0c} are presumably generated for the communication stations 1_b and 1_c, respectively (see arrow A in FIG. 2).

After such reservation phase, the data communication phase follows. Therein, the receiving station 1_R assembles one communication reservation packet 103 to inform each transmitting

station 1_T of the bandwidth reserved therefor. To be more specific, the receiving station 1_R assembles, as shown in FIG. 4c, the communication reservation packet 103 from the packet type T, the unique word UW, and the frame check sequence FCS in addition to the valid period VP.

Herein, the communication reservation packet 103 does not include the source identifier SID and the destination identifier DID for the purpose of making the packet length shorter. Without being included therewith, the communication reservation packet 103 is correctly received by the targeted transmitting station 1_T. As to a manner how to assemble the communication reservation packet 103, it is later described in step S63 in FIG. 7 and is not now described.

The unique word UW is typically the information necessary for the communication stations 1 receiving the communication reservation packet 103 (the transmitting stations 1_T) to identify the location of other information subsequent thereto (e.g., packet type T).

The packet type T is the information for identifying the communication reservation packet 103. The packet type T accordingly enables the transmitting stations 1_T to identify the received packet as the communication reservation packet 103.

The communication reservation packet 103 is provided with the valid period VP. Accordingly, the transmitting stations 1_T are each informed of the value of the valid period VP updated on

the receiving station 1_R side, and can judge the validity thereof.

INS A7

A7 ~~The frame check sequence FCS is the code for the communication stations 1 receiving the communication reservation packet 103 to judge whether or not any error is occurred in the communication reservation packet 103, or to correct any error occurred therein.~~

Such communication reservation packet 103 is sent out to the wireless transmission path 2 by the receiving station 1_R, and is then received by the targeted transmitting station 1_T for disassembly (sequence $Seq3_1$). In this example, the communication reservation packet 103 is presumably transmitted to the transmitting station 1_b.

The transmitting station 1_T divides data for transmission, according to a predetermined size, into several data blocks DB. After receiving the communication reservation packet 103, the transmitting station 1_T assembles a data packet 104 so as to transmit one of the data blocks DB to the receiving station 1_R. In more detail, the transmitting station 1_T assembles, as shown in FIG. 4d, the data packet 104 from the packet type T, the unique word UW, and the frame check sequence FCS in addition to the data block DB.

The unique word UW is typically the information necessary for the communication stations 1 receiving the data packet 104 (the receiving station 1_R) to identify the location of other information subsequent thereto (e.g., packet type T).

The packet type T is the information for identifying the data packet 104, and accordingly enables the receiving station 1_R to identify the received packet as the data packet 104.

Ins A8

A8 ~~The frame check sequence FCS is the code for the communication stations 1 receiving the data packet 104 to judge whether or not any error occurred in the data packet 104, or to correct any error occurred therein.~~

Herein, the data packet 104 is not provided with the source identifier SID and the destination identifier DID similarly to the communication reservation packet 103. Without being included therewith, the data packet 104 is correctly received by the targeted receiving station 1_R. As to a manner how to assemble the data packet 104, it is later described in step S143 in FIG. 10 and is not now described.

Such data packet 104 is sent out to the wireless transmission path 2 by the transmitting station 1_T, and is received by the receiving station 1_R for disassembly (sequence $Seq4_1$). In this example, the data packet 104 is presumably sent out by the communication station 1_b.

The receiving station 1_R repeats the transmission of the communication reservation packet 103 for N times (sequence $Seq3_1$ to 3_N) so as to receive the data packets 104 from the transmitting stations 1_T for disassembly. The receiving station 1_R then updates, in a manner corresponding to a status for receiving of each data packet 104, the valid period VP each provided to the

transmitting stations 1_T which transmitted the data packets 104. More specifically, if the receiving station 1_R received no data packet 104 from some transmitting station 1_T which was supposed to transmit the packet, the valid period provided thereto is shortened. If the receiving station 1_R received the data packet 104 from some transmitting station 1_T, the valid period provided thereto is lengthened.

Assuming that the communication station 1_b transmits the data packet 104 to the receiving station 1_R in response to the communication reservation packet 103 transmitted thereto in sequence $Seq3_1$ (sequence $Seq4_1$), the receiving station 1_R lengthens the valid period VP_b of the communication station 1_b (see arrow B in FIG. 2).

It is also assumed that the communication reservation packet 103 is transmitted to the communication station 1_c in sequence $Seq3_2$, however, the receiving station 1_R does not receive the data packet 104 therefrom for some reasons. If this is the case, the receiving station 1_R shortens the valid period VP_c of the communication station 1_c (see arrow C in FIG. 2).

In such manner, the data communication phase is through. Hereinafter, as shown in FIG. 2, both the reservation phase and the data communication phase are collectively referred to as a unit packet frame PF.

The communication procedure for the receiving station 1_R and the transmitting stations 1_T after such first unit packet frame

PF_1 is shown in FIG. 3. In FIG. 3, another reservation phase follows the first data communication phase, and the receiving station 1_R determines how many request inquiry packets 101 are to be transmitted in total M. Thereafter, the receiving station 1_R repeats the assembly and sending, to the transmission path 2, of the request inquiry packet 101 (sequences $Seq5_1$ to $Seq5_M$) so as to again collect requests for data communication from the transmitting stations 1_T. Thereafter, the receiving station 1_R reserves any bandwidth necessary for data communication for both the transmitting stations 1_T which newly transmitted the reservation request packets 102 this time and the transmitting stations 1_T to which the valid period VP has been each set so as to determine how many communication reservation packets 103 are to be transmitted in total N. Unlike the case for immediately after the startup of the communication system CS, the number N herein is preferably a value which ensures the transfer rate R required by both the transmitting stations 1_T which newly transmitted the reservation request packets 102 this time and the transmitting stations 1_T to which the valid period VP has been each set.

Furthermore, the receiving station 1_R generates information referred to as valid period VP for the transmitting stations 1_T which newly transmitted requests in this reservation phase (see arrow D in FIG. 3).

Hereinafter, in a similar manner to the above, data

communication is performed between the receiving station 1_R and the transmitting stations 1_T by exchanging the communication reservation packets 103 and the data packets 104 therebetween. In the communication system CS, the unit packet frame PF being the combination of the reservation phase and the data communication phase is repeated.

As is described in the foregoing, the valid period VP is lengthened or shortened. Therefore, if a certain transmitting station 1_T does not transmit the data packet 104 for some time, the valid period VP thereof becomes invalid in due time (that means, VP becomes equal to a given reference value VP_{REF}). When the valid period VP provided to some transmitting station 1_T becomes equal to the reference value VP_{REF}, the receiving station 1_R releases a bandwidth reserved for the transmitting station 1_T, and stops assembling the communication reservation packet 103 therefor in the following data communication phase (see arrow E in FIG. 3). In other words, the receiving station 1_R voluntarily keeps assembling the communication reservation packet 103 for transmission to the transmitting station 1_T until the valid period provided thereto becomes equal to the reference value VP_{REF}.

In the example in FIG. 3, the communication station 1_c receives the communication reservation packet 103 from the receiving station 1_R (see sequence $Seq6_2$) but does not transmit the data packet 104. Therefore, in the course of time, the valid period VP thereof becomes equal to the reference value VP_{REF} (see

arrow E), consequently the receiving station 1_R stops transmitting the communication reservation packet 103 thereto (see the third packet frame PF, for example).

The typical communication procedure in the communication system CS has been described. Note that, as shown in FIG. 1, each communication station 1 is typically structured by a communication controller 11, a counter 12, a storage device 13, a transmitter 14, and a receiver 15 for implementation of such communication procedure. Note that, for convenience, FIG. 1 only shows the communication stations 1_a and 1_b by internal structure thereof.

Hereinafter, for the purpose of structurally distinguishing between the receiving station 1_R and the transmitting station 1_T, each constituent of the receiving station 1_R is provided with a small "R" next to the reference numeral thereof. For example, the communication controller 11 provided in the receiving station 1_R is denoted by 11_R. On the other hand, each constituent of the transmitting station 1_T is provided with a small "T" next to the reference numeral thereof. For example, the storage device 13 provided in the transmitting station 1_T is denoted by 13_T.

INS A9

First, by referring to FIG. 5, the processing carried out by the receiving station 1_R is described in detail. The communication controller 11_R sets the transmission probability value P (where P satisfies $0 \leqq P \leqq 1$) to an initial value P_0 (step

~~S1). The initial value P_0 is set in accord with the design specifications of the communication system CS. As to the transmission probability value P, it is later described by referring to steps S134 and S135 in FIG. 9, and is not now described.~~

INS A^{10}

A^{10} ~~Next, the communication controller 11_R sets the number M, which indicates how many request inquiry packets 101 are to be transmitted, to an initial value M_0 (step S2). The initial value M_0 is set in accord with the design specifications of the communication system CS.~~

Thereafter, the communication controller 11_R goes to the reservation phase (step S3). FIG. 6 is a detailed flowchart illustrating step S3. In FIG. 6, the communication controller 11_R assembles one request inquiry packet 101 from the source identifier SID (that is, the identifier ID assigned to the receiving station 1_R), the packet type T, the unique word UW, and the frame check sequence FCS in addition to the current transmission probability value P. The request inquiry packet 101 (see FIG. 4a) is sent out to the wireless transmission path 2 via the transmitter 14_R (step S31).

INS A^{11}

A^{11} ~~Next, the communication controller 11_R judges whether or not any signal (any one of the packets 101 to 104) has arrived from the wireless transmission path 2 via the receiver 15_R (step S32). If no signal has arrived, the procedure goes to later-described step S38. If yes, the communication controller 11_R~~

judges whether or not the unique word UW included in the received signal can be detected. This tells whether or not any communication collision has currently occurred on the wireless transmission path 2 (step S33).

If the unique word UW is defective and thus cannot be detected, the communication controller 11_R judges that some communication collision has currently occurred on the wireless transmission path 2, and thus the procedure goes to later-described step S37. If the unique word UW is detected in step S33, the communication controller 11_R judges that no communication collision has currently occurred on the wireless transmission path 2. The procedure thus goes to step S34 so that the communication controller 11_R disassembles the received packet.

INS A12

A12 In step S34 (packet disassembly processing), the communication controller 11_R judges whether or not the received signal is the reservation request packet 102 addressed to the receiving station 1_R. To be more specific, the communication controller 11_R extracts the packet type T on the basis of the detected unique word UW. When the packet type T indicates the reservation request packet 102 (see FIG. 4b), the communication controller 11_R then extracts the destination identifier DID so as to judge whether or not the DID is the one provided to the receiving station 1_R.

When received the reservation request packet 102 addressed to the receiving station 1_R, the communication controller 11_R

extracts the transfer rate R and the source identifier SID therefrom. Further, the communication controller 11_R generates the valid period VP whose initial value is VP_0. The communication controller 11_R then registers, as shown in FIG. 11a, the transfer rate R, the identifier SID, and the valid period VP in the storage device 13_R as a set (step S35), and the procedure goes to step S36.

In the communication system CS, other communication stations 1 may be also in the middle of data communication at the same time. It means, in step S34, the communication controller 11_R may extract wrong identifier ID assigned to those other communication stations 1. Furthermore, even if the communication controller 11_R successfully extracts correct identifier ID in step S34, the packet type T may not indicate the reservation request packet 102. If this is the case, the communication controller 11_R discards the received signal, and the procedure goes to step S36.

In a case where step S34 is carried out, it means any one of the packets 101 to 104 is correctly received by the communication controller 11_R. This tells that the wireless transmission path 2 is in a state where a probability of communication collision is relatively low. Therefore, the communication controller 11_R adds a given value ΔP_1 (where Δp_1 satisfies $0 < \Delta P_1 < 1$) to the current transmission probability value P (step S36). In this manner, the transmission probability value

P set to another request inquiry packet 101 assembled in the next reservation phase is larger.

Step S33 is referred to again. When the communication controller 11_R cannot detect the unique word UW, it tells that the wireless transmission path 2 is in a state where the probability of communication collision is relatively high. If this is the case, the communication controller 11_R deducts a given value ΔP_2 (where Δp_2 satisfies $\Delta P_2 < 1$, or $\Delta P_1 = \Delta P_2$) from the current transmission probability value P (step S37). In this manner, the transmission probability value P set to another request inquiry packet 101 assembled in the next reservation phase is smaller.

Step S32 is referred to again. When the communication controller 11_R could not detect any signal arrived from the wireless transmission path 2, the communication controller 11_R judges whether or not a predetermined time T_{PRE1} has elapsed since the request inquiry packet 101 was transmitted (step S38).

The time T_{PRE1} is assumptive that the reservation request packet 102 addressed to the receiving station 1_R would have reached there by the time. More specifically, the time T_{PRE1} is a sum of time required for the request inquiry packet 101 to be transferred from the receiving station 1_R to the transmitting stations 1_T, time required for the transmitting stations 1_T to send out the reservation request packets 102 to the wireless transmission path 2 after each received the request inquiry packet 101, time required for the reservation request packet 102 to be

transferred from the transmitting stations 1_T to the receiving station 1_R, and a time margin.

If the time T_{PRE1} is not passed yet in step S38, the reservation request packet 102 addressed to the receiving station 1_R is yet likely to be transmitted. Thus, the procedure returns to step S32 so that the communication controller 11_R waits for any signal to be arrived from the wireless transmission path 2.

If the time T_{PRE1} has been passed, the communication controller 11_R judges that the reservation request packet 102 addressed to the receiving station 1_R is unlikely to be transmitted, and thus the procedure goes to step S36. If this is the case, it also means that no signal has transferred onto the wireless transmission path 2 for the duration of time T_{PRE1}, and thus the wireless transmission path 2 is in a state where the probability of communication collision is relatively low. Therefore, the communication controller 11_R adds a given value ΔP_1 (where ΔP_1 satisfies $\Delta P_1 \leqq 1$) to the current transmission probability value P (step S36).

After step S36 or S37, the communication controller 11_R is now through with the reservation phase (step S3) in FIG. 5, and next judges whether M pieces of request inquiry packets 101 have been transmitted (step S4). In step S4 for the first reservation phase, it is judged whether the M_0 piece(s) of request inquiry packet 101 is transmitted.

If M pieces of request inquiry packets 101 are not

transmitted yet, the communication controller 11_R goes to the reservation phase in step S3 again so as to send out a new request inquiry packet 101 to the wireless transmission path 2. If the M pieces of request inquiry packets 101 have been transmitted, the procedure goes to step S5.

By the time the procedure reaches step S5, the communication controller 11_R may have received one or more reservation request packets 102 from the transmitting stations 1_T, and as shown in FIG. 11b, may have registered the transfer rate R, the identifier ID, and the valid period VP in the storage device 13_R as a set for every transmitting station 1_T. The communication controller 11_R defines a transmission frequency TF for every registered transmitting station 1_T (step S5). More specifically, the transmission frequency TF is a value indicating how many communication reservation packets 103 are to be transmitted for one transmitting station 1_T within one unit packet frame PF. Accordingly, the sum of the transmission frequency TF defined for every transmitting station 1_T is equal to the number N shown in FIG. 2. The transmission frequency TF for every transmitting station 1_T is also registered in the storage device 13_R as shown in FIG. 11c.

Next, the communication controller 11_R goes to the data communication phase for processing (step S6). FIG. 7 is a detailed flowchart illustrating step S6.

In FIG. 7, the communication controller 11_R first selects

one identifier ID from the storage device 13_R (see FIG. 11a, 11b, or 11c) (step S61). In this manner, the communication controller 11_R selects the destination of the packet in this processing.

INS A^{13}

A^{13} ~~Second, the communication controller 11_R decides if having data for transmission to the selected transmitting station 1_T (step S62). The judgement in step S62 is dependent on if the communication controller 11_R has received, exemplarily from an application in the upper layer, any data for transmission to the transmitting station 1_T selected in step S61.~~

If the communication controller 11_R has no data for transmission to the selected transmitting station 1_T, the procedure goes to step S63. If any, the procedure goes to later-described step S610.

In step S63, the communication controller 11_R retrieves, from the storage device 13_R, the identifier ID selected in step S61 and the valid period VP found in the same set as the ID. The identifier ID of the transmitting station 1_T is used as the destination identifier DID for the communication reservation packet 103 to be transmitted in this processing. The communication controller 11_R also obtains the identifier ID of the receiving station 1_R and the packet type T indicating the communication reservation packet 103. The identifier ID of the receiving station 1_R is used as the source identifier SID for the communication reservation packet 103 to be transmitted in this processing.

The communication controller 11_R calculates a first CRC (Cyclic Redundancy Check) value according to the packet type T, the source identifier SID, the destination identifier DID, and the valid period VP. The first CRC value is obtained from a given generation polynomial as a function of the details of the packet type T, the source identifier SID, the destination identifier DID, and the valid period VP. The first CRC value is used as the frame check sequence to be set to the communication reservation packet 103 to be transmitted in this processing.

The communication controller 11_R then assembles the communication reservation packet 103 (see FIG. 4c) from the packet type T, the unique word UW, the newly obtained frame check sequence FCS in addition to the valid period VP. Herein, as is described in the foregoing, the communication reservation packet 103 does not include the source identifier SID and the destination identifier DID therein. The communication reservation packet 103 is sent out to the wireless transmission path 2 via the transmitter 14_R (step S63), and is received by the transmitting station 1_T.

A14 Next, the communication controller 11_R judges whether or not the data packet 104 (see FIG. 4d) addressed to the receiving station 1_R has arrived from the wireless transmission path 2 via the receiver 15_R (Step S64). As to the reception operation in step S64, it is later described by referring to step S143 in FIG. 10, and is not now described.

INS A15

A16 When received the data packet 104 addressed to the receiving station 1_R, the communication controller 11_R lengthens the valid period VP found in the same set as the selected identifier ID (Step S65). In this embodiment, in step S65, the communication controller 11_R exemplarily decrements the current valid period VP by the given value ΔVP_1 (where ΔVP_1 is an arbitrary number) so as to lengthen the valid period VP.

The communication controller 11_R is now through with the data communication phase in FIG. 5 (step 6), and the procedure goes to step S7.

INS A16

A16 If not received the data packet 104 addressed to the receiving station 1_R in step S64, the communication controller 11_R judges whether or not a predetermined time T_{PRE2} has elapsed since the communication reservation packet 103 was sent out (step S66).

The time T_{PRE2} is assumptive that the data packet 104 from the transmitting station 1_T which received the communication reservation packet 103 would have reached the receiving station 1_R by the time. More specifically, the time T_{PRE2} is a sum of time required for the communication reservation packet 103 to be transferred from the receiving station 1_R to the transmitting station 1_T, time required for the transmitting station 1_T to send out the data packet 104 to the wireless transmission path 2 after received the communication reservation packet 103, time required for the data packet 104 to be transferred from the transmitting

station 1_T to the receiving station 1_R, and a time margin.

If the time T_{PRE2} is not passed yet in step S66, the procedure returns to step S64 so that the communication controller 11_R waits for the data packet 104.

If the given time T_{PRE2} has been passed, the communication controller 11_R can judge that the transmitting station 1_T which has received the communication reservation packet 103 did not transmit the data packet 104, and thus shortens the valid period VP found in the same set as the selected identifier ID (Step S67). In this embodiment, in step S67, the communication controller 11_R exemplarily increments the current valid period VP by the given value ΔVP_2 (where ΔVP_2 is an arbitrary number) so as to shorten the valid period VP.

Next, the communication controller 11_R compares the shortened valid period VP with the given reference value VP_{REF} (step S66). In this embodiment, the valid period VP is lengthened after decremented by the value ΔVP_1, and is shortened after incremented by the value ΔVP_2. In such case, the reference value VP_{REF} needs to satisfy $VP_0 < VP_{REF}$.

If the valid period VP is less than the reference value VP_{REF}, the communication controller 11_R is through with the data communication phase in FIG. 5 (step S6) so as to keep the bandwidth reserved for the transmitting station 1_T. Thus, the procedure goes to step S7.

If the valid period VP is equal to or more than the reference

value VP_{REF}, the communication controller 11_R deletes, so as to release the bandwidth reserved for the transmitting station 1_T, the identifier ID of the transmitting station 1_T, and the transfer rate R, the valid period VP, and the transmission frequency TF found in the same set as the identifier ID from the storage device 13_R (step S69). The communication controller 11_R is now through with step S6, and the procedure goes to step S7.

Herein, step S62 is referred to again. While the receiving station 1_R is receiving data from the transmitting station 1_T, some data may be generated in the receiving station 1_R for transmission to the transmitting station 1_T. Accordingly, if the receiving station 1_R has any data for transmission to the transmitting station 1_T in step S62, the communication controller 11_R divides the data into several data blocks DB before the procedure goes to step S610.

Next, the communication controller 11_R obtains, for the data packet 104, the packet type T, the identifier ID of the receiving station 1_R, and the identifier ID of the transmitting station 1_T, and one of the data blocks DB. Herein, the identifier ID of the receiving station 1_R and the identifier ID of the transmitting station 1_T are respectively used as the source identifier SID and the destination identifier DID of the to-be-assembled data packet 104.

The communication controller 11_R calculates a first CRC value for the frame check sequence FCS for the data packet 104

to be assembled. The first CRC value is calculated by substituting the function of the details of the packet type T, the source identifier SID, the destination identifier DID, and the valid period VP to the above described generation polynomial.

Thereafter, the communication controller 11_R assembles the data packet 104. Herein, the communication controller 11_R assembles such data packet 104 as shown in FIG. 4d from the packet type T, the unique word UW, and the frame check sequence FCS in addition to the data block DB. Note that, the data packet 104 does not include the destination identifier DID and the source identifier SID for the purpose of making the packet length shorter.

The communication controller 11_R sends out the assembled data packet 104 to the wireless transmission path 2 via the transmitter 14_R (step S610), and the procedure goes to step S64.

A17

1/05 A17

After being through with step S6, the communication controller 11_R judges whether or not N pieces of communication reservation packets 103 have been sent out (step S7).

If not yet, the communication controller 11_R goes to step S6 again so as to send out a new communication reservation packet 103 to the wireless transmission path 2.

If N piece(s) of communication reservation packets 103 have been sent out, the procedure goes to step S8.

By the time the procedure reaches step S8, one unit packet frame PF (see FIG. 2 or 3) has been through. The communication

controller 11_R determines how many request inquiry packets 101 are to be transmitted in total M for the next unit packet frame PF (step S8). Although any manner will do to determine the number M, it is preferable to be based on how much bandwidth being left unused. To be specific, preferably, the more bandwidth being left unused, the larger the number M becomes.

After the number M is determined for the next unit packet frame PF, the procedure returns to step S3 so that the communication controller 11_R repeats the reservation phase and the data communication phase in the same manner as the above, and receives data from the transmitting stations 1_T.

1/1/5 A18

A18 Next, by referring to FIG. 8 for flowchart, it is described in detail how one transmitting station 1_T is operated to process. In FIG. 8, the communication controller 11_T receives data for transmission to a certain communication station 1 (the receiving station 1_R), the transfer rate R necessary for the data transmission, and the identifier ID of the receiving station 1_R from an application in an upper layer or an interface (step S11), and the procedure goes to step S12.

Then, the communication controller 11_T sets a value C of the counter 12_T to an initial value C_0 (step S12). The value C of the counter 12_T is substantially the same as the valid period VP controlled on the receiving station 1_R side.

1/1/6 A19

A19 Further, immediately after step S11 being through, the receiving station 1_R does not yet reserve any bandwidth for the

transmitting station 1_T. Accordingly, at this point in time, the valid period VP of the transmitting station 1_T is regarded as having reached the reference value VP_{REF} and being invalid. By taking this into consideration, the initial value C_0 is preferably not less than the reference value VP_{REF} of the valid period VP. More preferably, the initial value C_0 is set to be equal to the reference value VP_{REF}.

Thereafter, the communication controller 11_T goes to the reservation phase (step S13). FIG. 9 is a detailed flowchart illustrating step S13. In FIG. 9, the communication controller 11_T compares the current value C of the counter 12_T with an internally-stored reference value C_{REF} (step S131). It is preferable that the reference value C_{REF} being equal to the VP_{REF} on the receiving station side 1_R.

When the current value C is less than the reference value C_{REF}, the communication controller 11_T regards that the valid period VP of the transmitting station 1_T is yet valid, and the procedure skips steps onward (steps S132 to S137) and goes to the data communication phase in step S14.

When the current value C is equal to the reference value C_{REF} or more, the communication controller 11_T judges it as being immediately after data for transmission to the receiving station 1_R is generated or some bandwidth once assigned to the transmitting station 1_T is released by the receiving station 1_R, and then starts detecting a no-signal period TP_{NS} (step S132). The no-signal

period TP_{NS} is selected according to the design specifications of the communication system CS, and more specifically, indicates time required from a certain request inquiry packet 101 being received by the transmitting station 1_T to the next request inquiry packet 101 being transferred thereto, and a time margin.

INS A30

A30 Thereafter, the communication controller 11_T judges whether or not the request inquiry packet 101 (see FIG. 4a) is transmitted from the receiving station 1_R through both the wireless transmission path 2 and the receiver 15_T (step S133).

INS A31

A31 The reception operation in step S133 is described next below. First, when received some signal from the wireless transmission path 2, the communication controller 11_T detects the unique word UW included therein. Then, the communication controller 11_T extracts the packet type T subsequent to the unique word UW. If the packet type T indicates the request inquiry packet 101, the communication controller 11_T extracts the source identifier SID. When the source identifier SID coincides with the identifier ID of the receiving station 1_R obtained in step S11, the communication controller 11_T regards as received the request inquiry packet 101 from the receiving station 1_R, and the procedure goes to step S134. When the communication controller 11_T regards that the received signal is not the request inquiry packet 101 from the receiving station 1_R, discards the received signal and the procedure goes to later-described step S137.

In step S134, the communication controller 11_T generates

a random number RN (where RN satisfies 0 < RN ≦ 1). The communication controller 11_T also extracts the transmission probability value P from the received request inquiry packet 101 (step S134).

1/15 A22

A23 Then, the communication controller 11_T compares the random number RN obtained in step S134 with the transmission probability value P for the judgement whether or not the random number RN satisfies a given criterion (step S135). If satisfied, the communication controller 11_T judges that the transmission of the reservation request packet 102 is permitted, and the procedure goes to step S136. If not satisfied, the procedure returns to step S132 so that the communication controller 11_T starts detecting the no-signal period TP_{NS} and then waits for a new request inquiry packet 101.

1/15 A23

A23 The judgement operation in step S135 is exemplarily described next below. The transmission probability value P is the probability of the transmission of the reservation request packet 102 in response to the request inquiry packet 101 received by the transmitting station 1_T. For example, the transmission probability value P of 0.3 indicates that the transmitting station 1_T is allowed to transmit the reservation request packet 102 with a probability of 30%. The random number RN takes any number among 0.1, 0.2 ... 1. If this is the case, the communication controller 11_T compares the generated random number RN with the transmission probability value P so as to judge whether or not RN≦P is satisfied.

If satisfied, the communication controller 11_T regards that the transmission of the reservation request packet 102 is permitted, and the procedure goes to step S136. If not satisfied, the procedure returns to step S132.

In step S136, the communication controller 11_T assembles the reservation request packet 102 (see FIG. 4b) from the identifier ID of the receiving station 1_R obtained as the destination identifier DID exemplarily in step S11, the identifier ID of the transmitting station 1_T as the source identifier SID, the packet type T indicating the reservation request packet 102, the unique word UW, and the frame check sequence FCS in addition to the transfer rate R obtained in step S11, and sends out the packet to the wireless transmission path 2 via the transmitter 14_T (step S136). The communication controller 11_T is through with the reservation phase in FIG. 8 (step S13), and the procedure goes to step S14.

Note that, the reservation request packet 102 sent out to the wireless transmission path 2 is received by the receiving station 1_R. In response thereto, the receiving station 1_R goes to the processing described in step S35 in FIG. 6.

INS A^{24}

A^{24} Herein, step S133 is referred to again. When not received request inquiry packet 101, the communication controller 11_T judges whether or not the no-signal period TP_{NS} was detected on the wireless transmission path 2 (step S137).

INS A^{25}

A^{25} When not detected no-signal period TP_{NS}, the communication

controller 11_T decides that now is the time to transmit the reservation request packet 102, and the procedure goes to step S136. Then, the communication controller 11_T assembles the reservation request packet 102 in the same manner as the above for transmission to the receiving station 1_R (step S136). The communication controller 11_T is through with the reservation phase in FIG. 8 (step S13), and the procedure goes to step S14.

INS A24

A26 When not detected no-signal period TP_{NS} in step S137, the communication controller 11_T decides that now is not the time to transmit the reservation request packet 102. In this case, the procedure returns to step S132 so that the communication controller 11_T starts detecting the no-signal period TP_{NS} and waits for a new request inquiry packet 101.

The communication controller 11_T then goes to the data communication phase after being through the reservation phase (step S13 in FIG. 8)(step S14). FIG. 10 is a detailed flowchart illustrating step S14. In FIG. 10, the communication controller 11_T judges whether or not the communication reservation packet 103 (see FIG. 4c) addressed to the transmitting station 1_T is transmitted from the receiving station 1_R through the wireless transmission path 2 and the receiver 15_T (step S141).

As being peculiar to the present invention, the reception operation in step S141 is described by referring to FIG. 12a. After detected an incoming signal from the wireless transmission path 2, the communication controller 11_T detects the unique word

UW included therein. The communication controller 11_T then extracts the packet type T subsequent to the unique word UW (see arrow A).

When the packet type T indicates the communication reservation packet 103, the communication controller 11_T extracts the valid period VP from the received communication reservation packet 103 (see arrow B). The communication controller 11_T also retrieves the identifier ID of the receiving station 1_R obtained exemplarily in step S11 and the previously-stored identifier ID of the transmitting station 1_T (See arrows C and D). The communication controller 11_T substitutes the packet type T, the identifier ID of the receiving station 1_R, and the identifier ID of the transmitting station 1_T, and the valid period VP to the above-described generation polynomial so as to calculate a second CRC value for judgement (see arrow E).

As is described in step S63, the frame check sequence FCS of the communication reservation packet 103, i.e., the first CRC value is calculated from the packet type T, the source identifier SID (i.e., identifier ID of the receiving station 1_R), the destination identifier DID (i.e., identifier ID of the transmitting station 1_T), and the valid period VP. Accordingly, assuming that the transmitting station 1_T is the correct destination of the communication reservation packet 103, the second CRC value coincides with the first CRC value of the

communication reservation packet 103. If the values agree with each other, the communication controller 11_T regards that the received communication reservation packet 103 is the one addressed to the transmitting station 1_T, and no error is detected therein.

When the communication controller 11_T could not receive the communication reservation packet 103 addressed to the transmitting station 1_T in step S141, the procedure goes to later-described step S145. On the other hand, when received, the communication controller 11_T so updates the value C of the counter 12_T that the valid period VP controlled in the receiving station 1_R coincides therewith (step S142). In this manner, the value C of the counter 12_T is synchronized with the valid period VP.

Next, the communication controller 11_T obtains, for the data packet 104, the packet type T, the identifier ID of the transmitting station 1_T, the identifier ID of the receiving station 1_R, and one data block DB. Herein, the identifier ID of the transmitting station 1_T and the identifier ID of the receiving station 1_R are respectively used as the source identifier SID and the destination identifier DID for the data packet 104 to be assembled.

The communication controller 11_T calculates the first CRC value for the data packet 104 to be assembled as the frame check sequence FCS. The first CRC value is calculated by substituting, to the above-described generation polynomial, the function of the

details of the data packet T, the source identifier SID, the destination identifier DID, and the data block DB.

Thereafter, the communication controller 11_T assembles the data packet 104. Herein, the communication controller 11_T assembles such data packet 104 as shown in FIG. 4d from the packet type T, the unique word UW, and the frame check sequence FCS in addition to the data block DB. Note that, the data packet 104 does not include the source identifier SID and the destination identifier DID for the purpose of making the packet length shorter.

The communication controller 11_T sends out the assembled data packet 104 to the wireless transmission path 2 via the transmitter 14_T (step S143). After receiving the data packet 104, the receiving station 1_R goes to the processing in step S64 in FIG. 7 so as to receive and disassemble the data packet 104.

Step S64 for the receiving station 1_R is now described by referring to FIG. 12b. The communication controller 11_R detects the unique word UW included in an incoming signal from the wireless transmission path 2, and then extracts the packet type T subsequent thereto (see arrow A).

When the packet type T indicates the data packet 104, the communication controller 11_R extracts the data block DB therefrom (see arrow B). The communication controller 11_R also extracts the identifier ID of the transmitting station 1_T obtained exemplarily in step S35, and the previously-stored identifier ID

of the receiving station 1_R (see arrows C and D). The communication controller 11_R substitutes, to the above-described generation polynomial, the packet type T, the identifier ID of the transmitting station 1_T, the identifier ID of the receiving station 1_R, and the data block DB so as to calculate the second CRC value for judgement (see arrow E).

The frame check sequence FCS of the data packet 104, i.e., the first CRC value is calculated, as described in step S143, from the packet type T, the source identifier SID (i.e., identifier ID of the transmitting station 1_T), the destination identifier DID (i.e., identifier ID of the receiving station 1_R), and the data block DB. Accordingly, assuming that the receiving station 1_R is the correct destination of the data packet 104, the calculated second CRC value coincides with the first CRC value of the data packet 104. When the values agree with each other, the communication controller 11_R regards that the received data packet 104 is the one addressed to the receiving station 1_R and no error is detected therein, and the procedure goes to step S65 in FIG. 7. When the values do not agree with each other, the procedure goes to step S66.

FIG. 10 is referred to again. Since the transmitting station 1_T has transmitted the data packet 104 in step S143, the valid period VP assigned thereto is lengthened on the receiving station 1_R side. Accordingly, after step S143 is through, the communication controller 11_T updates the current value C of the

counter 12_T (step S144). Since the receiving station 1_R lengthens the valid period VP by (VP − ΔVP) in this embodiment, the communication controller 11_T decrements the current value C of the counter 12_T by a given value ΔC. Herein, in order to synchronize between the value C of the transmitting station 1_T and the valid period VP of the receiving station 1_R, it is preferable that the value ΔC is equal to the value ΔVP.

INS A28

A28 ~~Next, the communication controller 11_T judges whether or not the current value C of the counter 12_T is equal to a reference value C_{REF} or more (step S145).~~

If the value C is less than reference value C_{REF}, the communication controller 11_T regards that the valid period of the transmitting station 1_T is still valid, and the procedure returns to S141 so that the communication controller 11_T keeps going through the data communication phase.

If the value C is not less than the reference value C_{REF} in step S145, it is useless for the communication controller 11_T going through the data communication phase. Thus, the communication controller 11_T is through with the data communication phase in FIG. 10 (step S14), and the procedure goes to step S15 in FIG. 8.

INS A29

A29 ~~Step S141 in FIG. 10 is referred to again. Immediately after the communication controller 11_T judged that the received signal is not the communication reservation packet 103 addressed to the transmitting station 1_T, the procedure goes to step S146.~~

Thereafter, the communication controller 11_T judges whether or not the data packet 104 (transmitted in step S610) addressed to the transmitting station 1_T has arrived (step S146). Since the reception operation in step S146 is similar to step S64 in FIG. 7 (see FIG. 12b), it is not described again.

In a case where the data packet 104 arrives the communication controller 11_T in step S146, the procedure goes through steps S143 and S144 before the communication controller 11_T being through with the data communication phase in FIG. 10 (step S14), and then the procedure goes to step S15 in FIG. 8.

INS A30

A30 On the other hand, when not received data packet 104, the communication controller 11_T judges whether or not a predetermined time T_{PRE3} has elapsed since the reservation request packet 102 was transmitted in step S136 (step S147).

The time T_{PRE3} is assumptive that the communication reservation packet 103 from the receiving station 1_R would have reached the transmitting station 1_T by the time. More specifically, the time T_{PRE3} is a sum of time required for the reservation request packet 102 to be transferred from the transmitting station 1_T to the receiving station 1_R, time required for the receiving station 1_R to send out the communication reservation packet 103 to the wireless transmission path 2 after received the reservation request packet 102, time required for the communication reservation packet 103 to be transferred from the receiving station 1_R to the transmitting station 1_T, and a

time margin.

If the predetermined time T_{PRE3} is not passed yet, the procedure returns to step S141 so that the communication controller 11_T waits for the communication reservation packet 103 addressed to the transmitting station 1_T.

If the predetermined time T_{PRE3} has been passed, the communication controller 11_T can regard that the communication reservation packet 103 which was supposed to be transmitted from the receiving station 1_R did not arrive. If this is the case, it is assumable that the receiving station 1_R shortens the valid period VP of the transmitting station 1_T, thus the procedure goes to step S148 so that the communication controller 11_T updates the current value C of the counter 12_T (step S148). In this embodiment, the receiving station 1_R shortens the valid period VP by (VP + ΔVP). Therefore, the communication controller 11_T increments the current value C of the counter 12_T by the value ΔC.

After step S148 is thorough, the communication controller 11_T is through with the data communication phase in FIG. 10 (step S14), and the procedure goes to step S15 in FIG. 8.

INS A31

A31 In step S15, the communication controller 11_T judges whether or not any data block DB is left for transmission to the receiving station 1_R (step S15). When there is any data block DB being left, the procedure returns to step S13 for the processing in FIG. 9 again. If not, the procedure returns to step S11 so that the communication controller 11_T waits for new data, for example.

The procedure for both the receiving stations 1_R and the transmitting stations 1_T is now thoroughly described in a specific manner. With the procedure, such communication shown in the sequence charts in FIGS. 13 and 14 is carried out between the receiving stations 1_R and the transmitting stations 1_T. It is assumed next below that the communication station 1_a operates as the receiving station 1_R, and the communication station 1_b operates as the transmitting station 1_T.

First, the communication station 1_a goes through steps S1 and S2 in FIG. 5. For convenience, the initial value P_0 of the transmission probability value P is "0.3", and the initial value M_0 of the transmission number M is "2". Next, the communication station 1_a assembles one request inquiry packet 101 (see FIG. 4a) (FIG. 6; step S31). The request inquiry packet 101 includes the identifier ID"a" as the source identifier SID and the transmission probability value P of "0.3", and is sent out to the transmission path 2 (sequence $Seq11_1$). Then, the communication station 1_a waits for the reservation request packet 102 addressed thereto from the communication stations 1 (except the communication station 1_a).

At the time of sequence $Seq11_1$, the communication station 1_b is through with steps S11 and S12 in FIG. 8, obtained the identifier ID"a" of the receiving station 1_R from an application in an upper layer etc., and set the initial value C_0 of the counter 12_b to "3".

After step S12 is through, the procedure goes to steps S131 and S132 in FIG. 9. Herein, the reference value C_{REF} is assumed to be "3".

The communication station 1_b then receives the request inquiry packet 101 transmitted in sequence $Seq11_1$ (step S133), and generates the random number RN (step S134). Assuming that the generated random number RN is "0.4", the communication station 1_b decides that "RN $\leqq$ P" is not satisfied since the transmission probability value P of the received request inquiry packet 101 is "0.3" (step S135, see arrow A in FIG. 13). Thus, the procedure returns to step S132, and the communication station 1_b waits for a new request inquiry packet 101.

As is described in the foregoing, the communication station 1_b does not transmit the reservation request packet 102. Assuming that none of other communication stations 1 responded to the request inquiry packet 101 transmitted in sequence $Seq11_1$, the communication station 1_a repeats the processing in steps S32 to S38 until the predetermined time T_{PRE1} is passed. The procedure then goes to step S36. If this is the case, the communication station 1_a presumably determines that the wireless transmission path 2 is not congested and increases the transmission probability value P to "0.4" (step S36).

Since the transmission number M is "2" and so far one request inquiry packet 101 has been transmitted, the procedure returns to step S3 after step S4 in FIG. 5.

The communication station 1_a then assembles one request inquiry packet 101 (step S31 in FIG. 6). The request inquiry packet 101 is provided with the transmission probability value P of "0.4", and is sent out to the wireless transmission path 2 (sequence $Seq11_2$). Thereafter, the communication station 1_a waits for the reservation request packet 102 addressed thereto.

During sequences $Seq11_1$ and $Seq11_2$, a loop which consists of steps S132, S133 and S137 is repeated. At this time, the communication station 1_b receives the request inquiry packet 101 transmitted in sequence $Seq11_2$ after received the request inquiry packet 101 transmitted in sequence $Seq11_1$ but before detecting the no-signal period TP_{NS}. Therefore, the procedure goes to step S134, and the communication station 1_b generates the random number RN. The random number RN herein is presumed to be "0.2". If this is the case, the communication station 1_b determines that "RN $\leqq$ P" is satisfied in step S135 since the current transmission probability value P is "0.4" (see arrow B in FIG. 13).

The procedure then goes to step S136 so that the communication station 1_b assembles one reservation request packet 102 (see FIG. 4b), sends out the packet to the communication station 1_a (sequence $Seq12_1$), and waits for the communication reservation packet 103 therefrom.

Although a loop which consists of steps S32 and S38 is repeated, the communication station 1_a may receive the reservation request packet 102 transmitted in sequence $Seq12_1$ before the

predetermined time T_{PRE1} is passed. Thus, the procedure goes to step S33 after step S32 is through. Assuming that currently no communication collision has occurred, the communication station 1_a disassembles the received packet in step S34 and regards that the reservation request packet 102 addressed has arrived. Thereafter, the communication station 1_a registers the transfer rate R, "b" as the source identification SID, and the initial value VP_0 of the valid period VP_b, which are extracted from the received reservation request packet 102, in the storage device 13_a as a set. Herein, the initial value VP_0 is assumed to be "3".

Thereafter, the transmission probability value P is increased (step S36). Then, since two request inquiry packets 101 have been transmitted, the procedure goes to step S5 after step S4 is through. At this point in time, the communication station 1_a has only received the reservation request packet 102 from the communication station 1_b, the transmission frequency TF with respect to the communication station 1_b is defined. The transmission frequency TF_b is assumed to be "2" (see arrow C in FIG. 13).

Next, the communication station 1_a selects "b" for the registered identifier ID, and then assembles the communication reservation packet 103 including the valid period VP_b of "3" (steps S61 to S63 in FIG. 7). To the communication reservation packet 103 in this example, the valid period VP_b of "3" is set. Further, to the frame check sequence FCS, the above-described first CRC

value is set. The communication station 1_a sends out the assembled communication reservation packet 103 to the communication station 1_b through the wireless transmission path 2 (sequence $Seq13_1$), then, waits for the data packet 104 addressed thereto.

INS A32 A32 After sent out the reservation request packet 102 in sequence $Seq12_1$, the communication station 1_b goes to the data communication phase in FIG. 10. Assuming that no signal (except the communication reservation packet 103) has been sent out to the wireless transmission path 2 during sequences $Seq12_1$ and $Seq13_1$, the communication station 1_b correctly receives the communication reservation packet 103, which is transmitted in sequence $Seq13_1$, in step S141 carried out immediately after sequence $Seq13_1$. At this time, as is described in the foregoing, the communication station 1_b calculates the second CRC value, and determines that the received packet is the communication reservation packet 103 addressed thereto.

Thereafter, the communication station 1_b so updates the value C of the counter 12_b that the valid period VP_b of the communication reservation packet 103 coincides therewith (step S142), and then assembles one data packet 104 (FIG. 4d) (step S143). Herein, to the frame check sequence FCS, the first CRC value is set. The communication station 1_b then transmits the assembled data packet 104 to the communication station 1_a through the wireless transmission path 2 (sequence $Seq14_1$).

INS A33 A33 Next, the communication station 1_b decrements the value C

of the counter 12_b by ΔC (step S144). If the value ΔC is assumed to be "1" in this example, the value C at this time is "2". Then, the communication station 1_b judges whether or not the current value C of the counter 12_b is equal to the reference value C_{REF} or more (step S145). Since the reference value C_{REF} is "3", the procedure returns to step S141 so that the communication station 1_b waits for a new communication reservation packet 103.

Herein, it is assumed that, after the communication station 1_a sent out the communication reservation packet 103 in sequence $Seq13_1$, a loop which consists of steps S64 and S66 in FIG. 7 is repeated during sequences $Seq13_1$ and $Seq14_1$. In such case, in step S64 immediately after sequence $Seq14_1$, the communication station 1_a receives the data packet 104 addressed thereto which was transmitted in sequence $seq14_1$. At this time, as described in the foregoing, the communication station 1_a calculates the second CRC value, determines that the received packet is the data packet 104 addressed thereto, and then extracts the data block DB for storage.

Thereafter, the procedure goes to step S65 so that the communication station 1_a decrements the valid period VP of the communication station 1_b registered in the storage device 13_a by ΔVP so as to lengthen the valid period VP. In this example, the value ΔVP is assumed to be "1" being equal to the value ΔC. Accordingly, the valid period VP_b of the communication station 1_b is currently "2" (see arrow D in FIG. 13).

The communication station 1_b is then through with the data communication phase in step S6, and the procedure goes to step S7. Since the communication station 1_a does not yet transmit the communication reservation packet 103 for the required number of pieces, the procedure returns to step S6 for the data communication phase (see FIG. 7) again.

After selected "b" for the registered identifier ID, the communication station 1_a assembles the communication reservation packet 103 including the valid period VP_b of "2" in the same manner as above (steps S61 to S63). The communication station 1_a then transmits the assembled communication reservation packet 103 to the communication station 1_b through the wireless transmission path 2 (sequence $Seq13_2$), and waits for the data packet 104 addressed thereto (steps S64 and S66).

After sent out the data packet 104 in sequence $Seq14_1$, the communication station 1_b goes to the reservation phase in FIG. 9. Since, at this time, the value C of the counter 12_b is "2" and the reference value C_{REF} is "3", the communication station 1_b skips the reservation phase to the data communication phase in FIG. 10. Assuming that no signal has been sent out to the wireless transmission path 2 during sequences $Seq14_1$ and $Seq13_2$, a loop which consists of steps S141, S146 and S147 is repeated. The communication station 1_b correctly receives, in step S141 immediately after sequence $Seq13_2$, the communication reservation packet 103 transmitted in sequence $Seq13_2$.

Then, the procedure goes to step S142 so that the communication station 1_b assembles one data packet 104 for transmission to the communication station 1_a through the wireless transmission path 2 (step S143, sequence $Seq14_2$).

A34 Next, the communication station 1_b decrements the value C of the counter 12_b by ΔC (step S144) so as to update the value to "1". If there is any data for transmission is left, the procedure returns to the reservation phase in step S13 after step S15 in FIG. 8 is through.

Assuming that no signal has been sent out to the wireless transmission path 2 during sequences $Seq13_2$ and $Seq14_2$, a loop which consists of steps S64 and S66 is repeated. The communication station 1_a receives, in step S64 immediately after sequence $Seq14_2$, the data packet 104 transmitted in sequence $Seq14_2$, and extracts the data block DB for storage.

The communication station 1_a then decrements the valid period VP of the communication station 1_b by ΔVP (Step S65) so as to update the value to "1".

The communication station 1_a is through with the data communication phase in step S6, and the procedure goes to step S7. Since the communication station 1_a has transmitted the communication reservation packet 103 for the required number of pieces, the procedure goes to step S8 so that the communication station 1_a determines the transmission number M for the next unit packet frame. In this example, the transmission number M is

presumably determined as "1".

Such sequence Seq11 to Seq14 forms the first unit packet frame PF_1.

The communication station 1_a then goes to the reservation phase in step S3, i.e., step S31 in FIG. 6, so as to assemble one request inquiry packet 101 for transmission to the wireless transmission path 2 (sequence $Seq15_1$). To the request inquiry packet 101, the transmission probability of "0.5" is set. Then, the communication station 1_a waits for the reservation request packet 102 from any communication station 1 having a request for data communication therewith.

For convenience, it is assumed herein that a plurality of communication stations 1 (except the communication station 1_b) concurrently transmit the reservation request packets 102 in response to the request inquiry packets 101 transmitted in sequence $Seq15_1$, and consequently some communication collision occurs on the wireless transmission path 2 (sequence $Seq16_1$).

Herein, although a loop which consists of steps S13 to S15 is repeated in sequence $Seq15_1$, the communication station 1_b goes to the data communication phase directly from step S131 in the reservation phase. Therefore, the communication station 1_b does not receive the request inquiry packet 101.

By referring to FIG. 14 for sequence cart, the communication procedure between the communication stations 1_a and 1_b is described next below.

After sequence $Seq15_1$, steps S32 to S38 are repeated. However, since the communication station 1_a receives several collided reservation request packets 102 before the predetermined time T_{PRE1} is passed, the procedure goes to step S37 after step S33. The communication station 1_a decreases the transmission probability value P (step S37) to "0.4". The procedure then returns to step S4 in FIG. 5. Since so far one request inquiry packet 101 has been transmitted, and the current transmission number M is "1", the procedure then goes to step S5. In this reservation phase, the communication station 1_a cannot correctly receive the reservation request packet 102 from the new communication stations 1. Therefore, in step S5, the transmission frequency TF_b with respect to the transmitting station 1_b is presumably determined as "2" again (see arrow F in FIG. 14).

Then, the procedure goes to steps S61 to S63 in FIG. 7 so that the communication station 1_a selects "b" for the registered identifier ID, and assembles the communication reservation packet 103 for transmission to the communication station 1_b (sequence $Seq17_1$). To the communication reservation packet 103, the valid period VP of "1" is set. Thereafter, the communication station 1_a waits for the data packet 104 addressed thereto.

The communication station 1_b has been waiting for the communication reservation packet 103 from the communication station 1_a after transmitted the data packet 104 in sequence $Seq14_2$,

and receives the communication reservation packet 103 in step S141 immediately after sequence $Seq17_1$.

Next, in step S142, the communication station 1_b first equalizes the value C of the counter 12_b with the valid period VP of "1", and in step S143, assembles one data packet 104 for transmission to the communication station 1_a through the wireless transmission path 2 (sequence $Seq18_1$).

The procedure then goes to step S144 so that the communication station 1_b decrements the value C of the counter 12_b by ΔC to obtain "0" (see arrow G in FIG. 14). Then, the communication station 1_b determines that there is no more data for transmission (data block) left (step S15), and the procedure returns to step S11 in FIG. 8.

Assuming that no signal has been sent out to the wireless transmission path 2 after the communication station 1_a transmitted the communication reservation packet 103 in sequence $Seq17_1$ but before sequence $Seq18_1$. If this is the case, in step S64 immediately after sequence $Seq18_1$, the communication station 1_a receives the data packet 104 transmitted in sequence $Seq18_1$ and then extracts the data block DB therefrom for storage. In this manner, the communication controller 11_a of the communication station 1_a may receive every data transmitted from the communication station 1_b, thus transmits the data to the application in the upper layer, for example.

The communication station 1_a decrements, by ΔVP, the valid

period VP_b of the communication station 1_b registered in the storage device 13_a to obtain "0" (step S65).

Although the procedure goes to step S7 in FIG. 5, since the communication station 1_a does not yet transmit the communication reservation packet 103 for the required number of pieces, the procedure returns to step S6 for the data communication phase again.

The communication station 1_a selects "b" for the registered identifier ID, and then, in a similar manner to the above, assembles the communication reservation packet 103 including the valid period VP_b of "0" (steps S61 to S63). The communication station 1_a transmits the assembled communication reservation packet 103 to the communication station 1_b through the wireless transmission path 2 (sequence $Seq17_2$), then waits for the data packet 104 therefrom.

Since the communication station 1_b has already transmitted every data to the communication station 1_a, now is waiting for new data to be transmitted from the application of the upper layer etc., and the like (step S11 in FIG. 8). Accordingly, the communication station 1_b neglects the communication reservation packet 103 transmitted in sequence $Seq17_2$. As a result, steps S64 and S66 are repeated thereafter, but the procedure soon goes to step S67 after S66.

The communication station 1_a then increments, by ΔVP, the valid period VP_b registered in the storage device 13_a to obtain

"1" (see arrow H in FIG. 14, step S67).

The communication station 1_a then judges whether the valid period VP_b is equal to the reference value VP_{REF} or more (step S68). Assuming that the reference value VP_{REF} is previously set to "4", the communication station 1_a is through with the data communication phase in FIG. 5 with the reason that the valid period VP_b is "1", and the procedure goes to step S7.

Since the communication station 1_a has already transmitted the communication reservation packet 103 for the required number of pieces, the procedure goes to step S8 so that the communication station 1_a determines the transmission number M for the next unit packet frame. In this example, the transmission number M is presumably determined as "1".

Such sequence Seq15 to Seq18 forms the second unit packet frame PF_2.

In the third unit packet frame PF_3 and onwards, the communication station 1_a operates in the same manner as in the unit packet frame PF_2 and transmits the communication reservation packet 103 to the communication station 1_b. However, as the communication station 1_b has been waiting for new data to be transmitted since sequence $Seq18_1$, and thus neglects the communication reservation packet 103 even if the packet is addressed thereto.

Accordingly, every time the communication station 1_a transmits the communication reservation packet 103 to the

communication station 1_b, the communication station 1_a goes to step S67 so as to shorten the valid period VP (see arrow I in FIG. 14). Consequently, the valid period VP of the communication station 1_b will be soon equalized with the reference value VP_{REF}. When determined that the valid period VP of the communication station 1_b is now equal to or more than the reference value VP_{REF} in step S68, the communication station 1_a deletes the set of transfer rate R_b, the identifier ID, the valid period VP_b, and the transmission frequency TF_b from the storage device 13_a in step S69. In this manner, the communication station 1_a releases the bandwidth reserved for the communication station 1_b (see arrow J in FIG. 14).

After the deletion, the communication station 1_a does not transmit the communication reservation packet 103 to the communication station 1_b unless the communication station 1_a receive any new reservation request packet 102 therefrom.

As described in the foregoing, the communication station 1_a operating as the receiving station 1_R reserves a bandwidth for the communication station 1_b as the transmitting station 1_T in response to the reservation request packet 102. In addition, for the purpose of controlling the reserved bandwidth, the communication station 1_a registers the identifier ID"b" of the communication station 1_b, the transfer rate R_b, the valid period VP_b, and the transmission frequency TF_b as a set in the storage device 13_a. Herein, the valid period VP_b is lengthened or

shortened depending on the data packet 104 transmitted from the communication station 1_T. The communication station 1_a voluntarily keeps transmitting, on the basis of the transmission frequency TF_b, the communication reservation packet 103 to the communication station 1_b as long as the valid period thereof is valid, and reserving the bandwidth therefor.

In this manner, as shown in FIGS. 13 and 14, as long as the valid period VP is valid after the transmission of the reservation request packet 102 to the communication station 1_a, the communication station 1_b can more swiftly transmit the data packet 104 by responding to the communication reservation packet 103 addressed thereto. As a result, in the communication system CS, the frequency of transmitting the reservation request packet 102 for bandwidth reservation is considerably reduced compared with the SRMA described in the Background Art. Accordingly, the overhead for the bandwidth reservation in this communication system CS is decreased, and thus bandwidths of the wireless transmission path 2 can be more effectively utilized.

Further, when it is assumed that any communication collision occurs on the wireless transmission path 2, the receiving station 1_R relatively lowers the transmission probability value P of the request inquiry packet 101. In this manner, even if the transmitting station 1_T has any data for transmission to the receiving station 1_R, the probability of transmission of the reservation request packet 102 is lowered.

It means that the transmitting station 1_T cannot transmit the reservation request packet 102 in some cases. As is known from this, the receiving station 1_R perform traffic control of the wireless transmission path 2 according to the transmission probability value P so as to prevent the wireless transmission path 2 from being congested.

Also, if the transmitting station 1_T transmits the data packet 104 less often, the valid period VP controlled on the receiving station 1_R side accordingly becomes invalid rather soon and thus the bandwidth reserved for the transmitting station 1_T is released. Accordingly, the bandwidths of the wireless transmission path 2 can be more effectively utilized.

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A35 Still further, in the communication system CS, the transmitting station 1_T and the receiving station 1_R can each obtain the partner's identifier ID for data communication before going through the data communication phase. Also, the transmitting station 1_T judges whether or not the communication reservation packet 103 is addressed thereto according to the first and second CRC values (see FIG. 12a or 12b), while the receiving station 1_R judges whether or not the data packet 104 is addressed thereto according to the first and second CRC values. In this manner, there is no more need to set the source identifier SID and the destination identifier DID to both the communication reservation packet 103 and the data packet 104. Accordingly, it becomes possible to make the packet length shorter, and thus the

bandwidths of the wireless transmission path 2 can be more effectively utilized.

Although the wireless transmission path 2 interconnects the communication stations 1 in the communication system CS, a wired transmission path will do.

When it is known in step S38 in FIG. 6 that the predetermined time T_{PRE1} is passed, the procedure goes to step S36. However, the lapse of predetermined time T_{PRE1} is enough for the receiving station 1_R to make a judgement that the wireless transmission path 2 has no incoming signal. Therefore, at this point in time, the receiving station 1_R may transmit the communication reservation packet 103 to any one of the communication stations 1 for which a bandwidth is reserved.

Still further, in steps S141 and S146 in FIG. 10, if the transmitting station 1_T cannot correctly receive the communication reservation packet 103 and the data packet 104 addressed thereto, the procedure goes to steps S146 and S147. However, in steps S141 and S146, the transmitting station 1_T may receive the communication reservation packet 103 and the data packet 104 which are not addressed thereto. If this is the case, the possibility for the wireless transmission path 2 being congested is low, therefore the transmitting station 1_T may transmit the reservation request packet 102 to a certain communication station 1 when having any data for transmission thereto.

Still further, in this embodiment, the receiving station 1_R lengthens the valid period VP on reception of the data packet 104 from the transmitting station 1_T in step S65 in FIG. 7. However, the receiving station 1_R may transmit, to the transmitting station 1_T, the communication reservation packet 103 which the transmitting station 1_T can transmit the data packet 104 with the length being relatively longer. In other words, the receiving station 1_R may dynamically change the transmission cycle of the communication reservation packet 103.

Still further, in the communication system CS, the receiving station 1_R controls reception of the data packet and assignment of bandwidths. However, one of the communication stations 1 may centrally control assignment of the bandwidths of the wireless transmission path 2, and other communication stations 1 may perform data communication therebetween.

In the communication procedure in FIGS. 13 and 14, the case where the transmitting station 1_T transmit data to the receiving station 1_R is described. However, in the communication system CS, some data may be generated in the receiving station 1_R for transmission to the transmitting station 1_T while the transmitting station 1_T is transmitting data thereto. If this is the case, the transmitting station 1_T and the receiving station 1_R perform two-way data communication by using the communication procedure as shown in FIG. 15. Next below, similarly to the cases in FIGS. 13 and 14, the communication station 1_a presumably

operates as the receiving station 1_R, and the communication station 1_b as the transmitting station 1_T.

The communication station 1_a transmits the request inquiry packet 101 in a similar manner to sequences $Seq11_1$ and $Seq11_2$ (FIG. 15; sequence $Seq21_1$), and receives the reservation request packet 102 from the transmitting station 1_b as a reply (sequence $Seq22_1$). The communication station 1_a disassembles the reservation request packet 102 and then reserves a bandwidth for the communication station 1_b. Thereafter, the communication station 1_a transmits the communication reservation packet 103 to the communication station 1_b in a similar manner to the sequences $Seq13_1$ and $Seq13_2$ (FIG. 15; sequences $Seq23_1$ and $Seq23_2$). The communication station 1_b assembles the data packet 104 in response to the communication reservation packet 103 as in sequences $Seq14_1$ and $Seq14_2$ for transmission to the communication station 1_a (sequences $Seq24_1$ and $Seq24_2$).

After receiving the data packet 104 transmitted in sequence $Seq24_2$, the communication station 1_a lengthens the valid period VP_b of the communication station 1_b (FIG. 7; step S65). If the communication station 1_a does not yet transmit the communication reservation packet 103 for the required number of pieces, the procedure goes to step S6 in FIG. 5 (that is, step S61 in FIG. 7). Assuming that the identifier ID of the communication station 1_b is again selected (step S61), the communication station 1_a decides if having any data for transmission thereto (step S62).

If any, the communication station 1_a assembles the data packet 104 for transmission thereto (sequence $Seq23_3$).

Thereafter, the communication station 1_a waits for the data packet 104 from the communication station 1_b.

After transmitted the data packet 104 to the communication station 1_a in sequence $Seq24_2$, the communication station 1_b is again waiting for the communication reservation packet 103 addressed thereto (steps S141 and S147 in FIG. 10). Then, the communication station 1_b detects, receives, and disassembles the packet on the wireless transmission path 2 after sequence 23_3 so as to determine if the received packet is the communication reservation packet 103 (step S141). Since the communication station 1_b notices, over disassembly, that the packet type T included therein does not indicate the communication reservation packet 103, the procedure goes to step S146.

Thereafter, the communication station 1_b decides that the received packet is the data packet 104 with the help of packet type T, and then further disassembles the packet to extract the data block DB therefrom (step S146). The procedure then goes to step S143 and onwards, and accordingly the communication station 1_b assembles the data packet 104 for transmission to the communication station 1_a responding to the data packet 104 therefrom (step S143, sequence $Seq24_3$). From then and onward, the communication station 1_a and 1_b exchange the data packet 104 therebetween.

While the invention has been described in detail, the foregoing description is in all aspects illustrative and not restrictive. It is understood that numerous other modifications and variations can be devised without departing from the scope of the invention.